CONTROL FOR AN I.S. MACHINE
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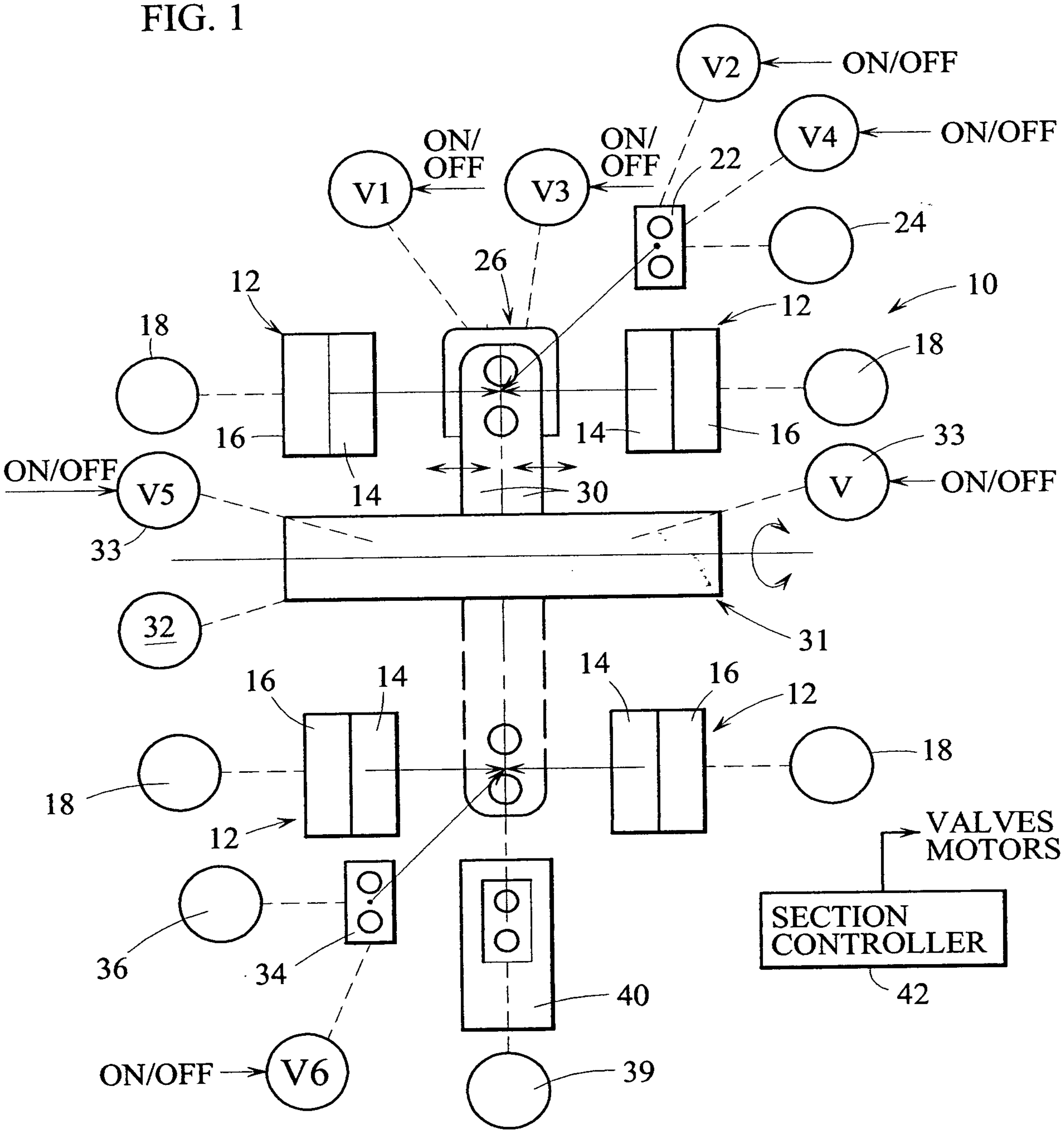
09/829,748 (5346-05)

4: 5

FIG. 1



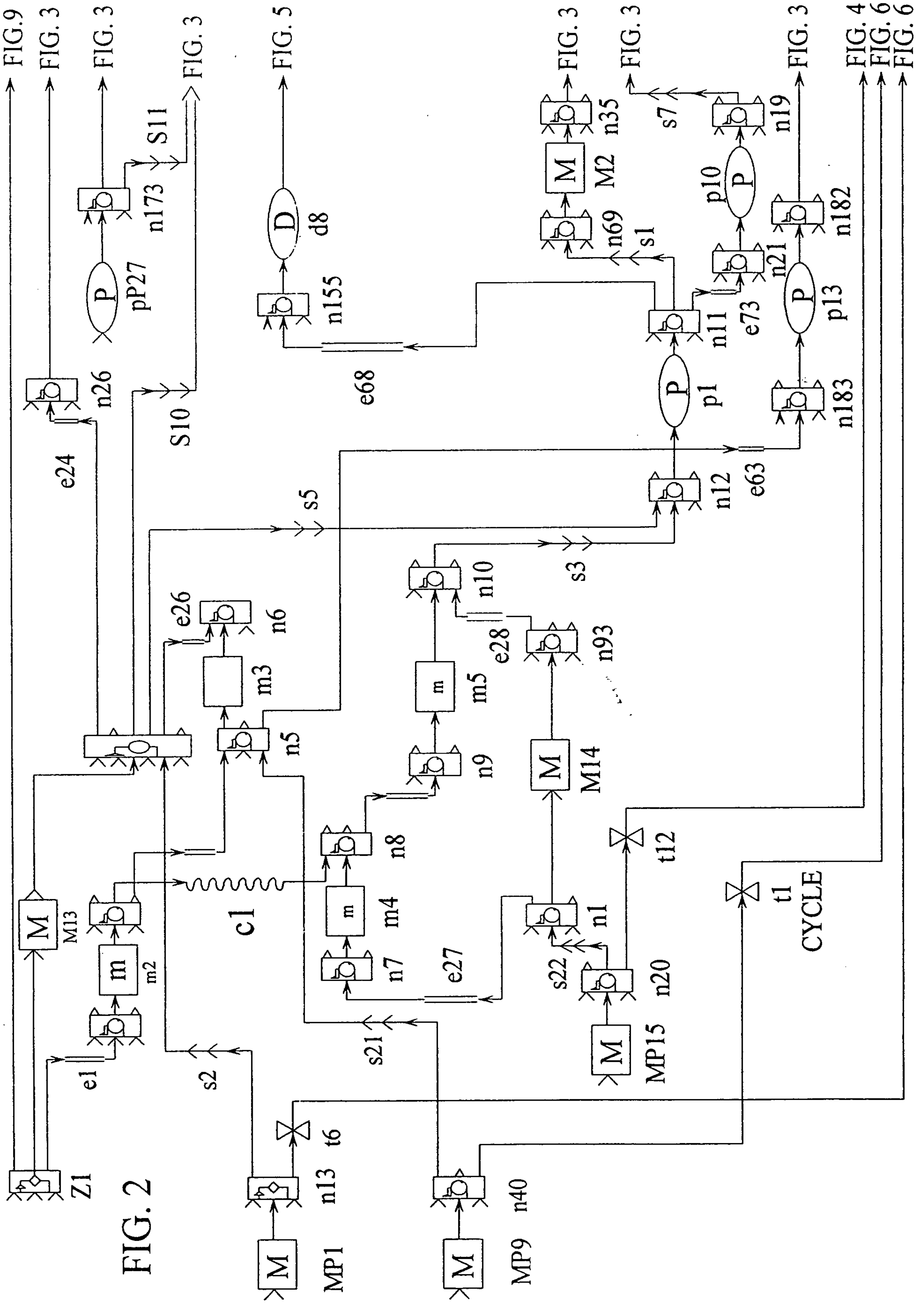


FIG.9
FIG. 3
FIG. 3
FIG. 3
FIG. 5
FIG. 3
FIG. 3
FIG. 3
FIG. 4
FIG. 6
FIG. 6
S11
n173
pP27
n26
e24
S10
D
d8
n155
e68
M2
n35
n69
s1
s7
n19
p10
n21
n11
e73
n182
p13
p1
n183
e63
n12
s5
s3
n10
e26
n6
m3
n5
e28
n93
m5
n9
M14
M13
m2
e1
c1
n8
m4
n7
e27
n1
t12
t1
CYCLE
s22
n20
s2
s21
MP15
Z1
n13
t6
n40
MP1
MP9
M
m
P

FIG. 2

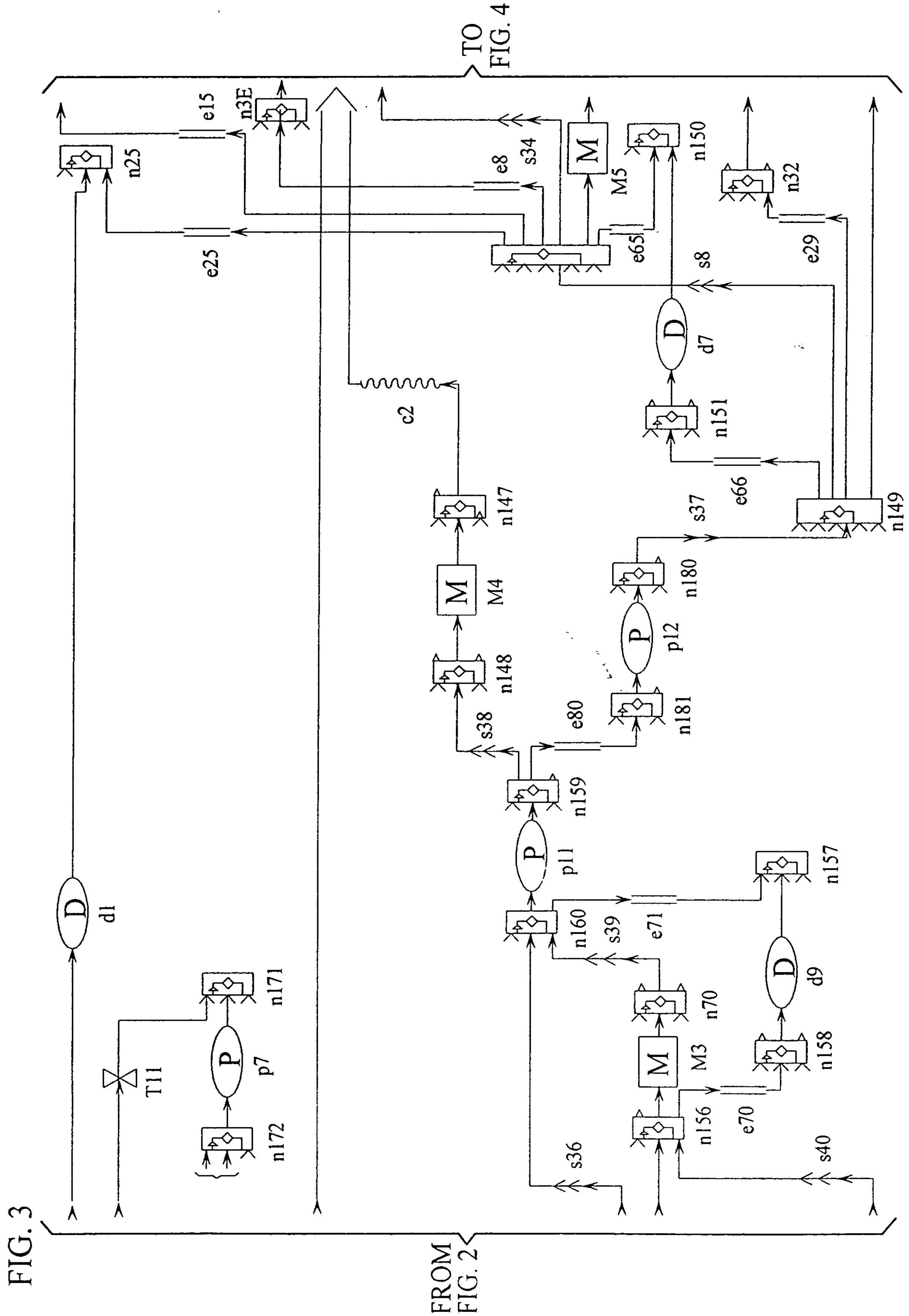

TO FIG. 4
FROM FIG. 2
n25
e15
n3E
e25
e8
s34
M
M5
e65
n150
s8
D
d7
n32
e29
c2
n151
e66
n147
s37
n149
M
M4
n180
P
p12
n148
n181
s38
e80
n159
P
p11
n160
s39
e71
n157
D
d1
n171
n70
D
d9
P
p7
T11
M
M3
n158
n172
n156
e70
s36
s40

FIG. 3

FIG. 4

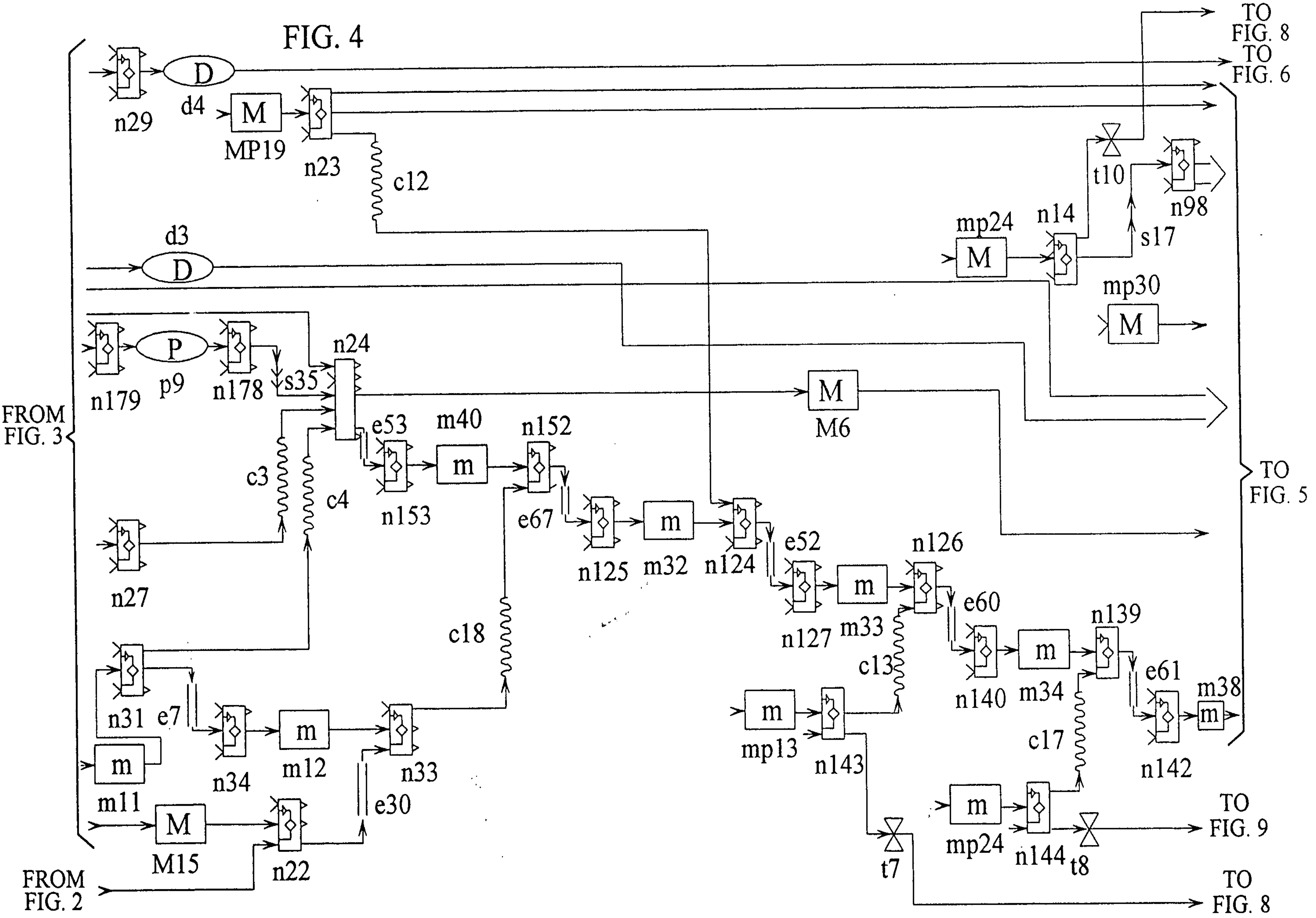
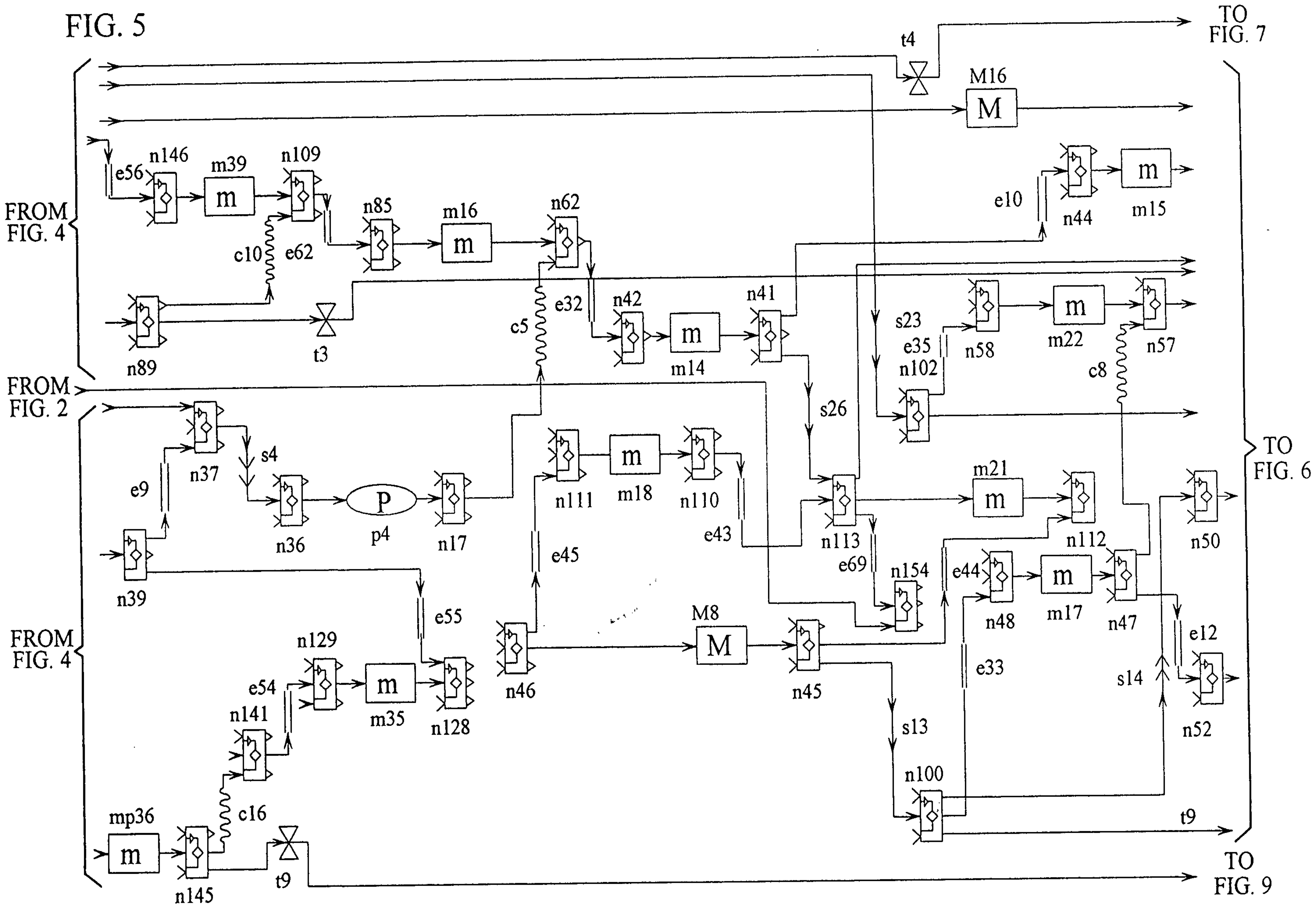

n29
D
d4
M
MP19
n23
c12
TO FIG. 8
TO FIG. 6
t10
n98
s17
n14
mp24
M
d3
D
mp30
M
FROM FIG. 3
n179
P
p9
n178
s35
n24
M
M6
TO FIG. 5
e53
m40
m
n152
c3
c4
n153
e67
n125
m
m32
n124
e52
n27
n126
m
n127
m33
e60
c18
c13
m
n140
m34
n139
e61
m38
m
n31
e7
m
n34
m
m12
n33
mp13
m
n143
c17
n142
m11
m
M
M15
n22
e30
mp24
m
n144
t8
TO FIG. 9
t7
FROM FIG. 2
TO FIG. 8

FIG. 5


TO FIG. 7
t4
M16
M
n146
e56
m39
m
n109
n85
m16
m
n62
e10
n44
m
m15
FROM FIG. 4
c10
e62
n89
t3
c5
e32
n42
m
m14
n41
s23
e35
n102
n58
m
m22
n57
c8
FROM FIG. 2
s26
n37
s4
e9
n36
P
p4
n17
n111
m
m18
n110
e43
n113
m21
m
n112
n50
TO FIG. 6
n39
e45
e69
n154
e44
n48
m
m17
n47
e55
M8
M
e12
FROM FIG. 4
n129
e54
m
m35
n128
n46
n45
e33
s14
n52
n141
s13
n100
mp36
m
c16
t9
t9
n145
TO FIG. 9

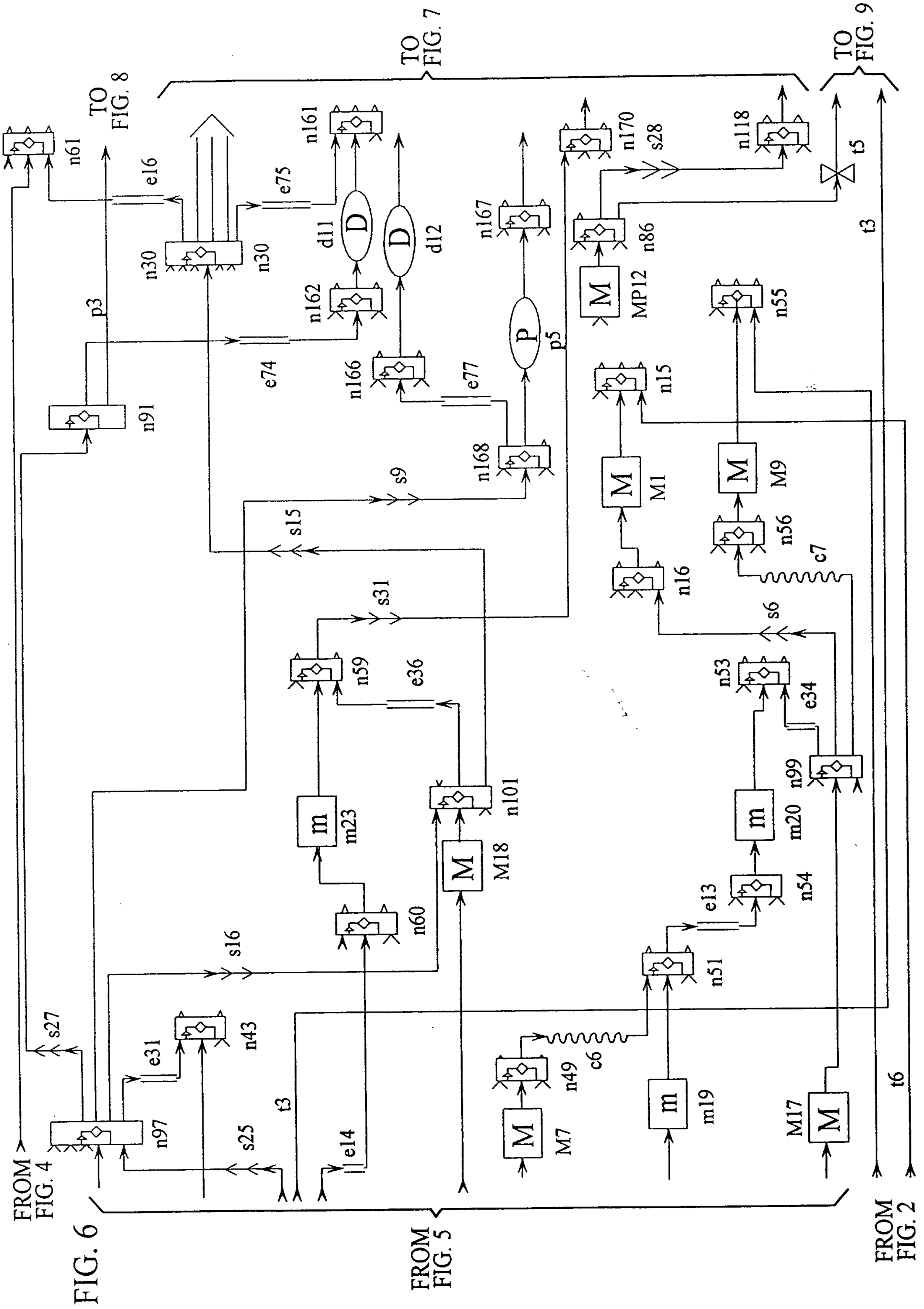

TO FIG. 8
TO FIG. 7
TO FIG. 9
FROM FIG. 4
FROM FIG. 5
FROM FIG. 2
n61
e16
p3
n30
n30
e75
n161
d11
d12
n162
n166
e74
e77
n91
n167
P
p5
n168
n170
s28
n118
t5
n86
MP12
t3
n15
n55
M1
M9
n16
n56
c7
s9
s15
s31
s6
n59
e36
n53
e34
n99
n101
m23
M18
m20
n54
e13
n60
s16
n51
s27
n43
e31
c6
n49
n97
s25
t3
e14
M7
m19
M17
t6

FIG. 6

FIG. 7

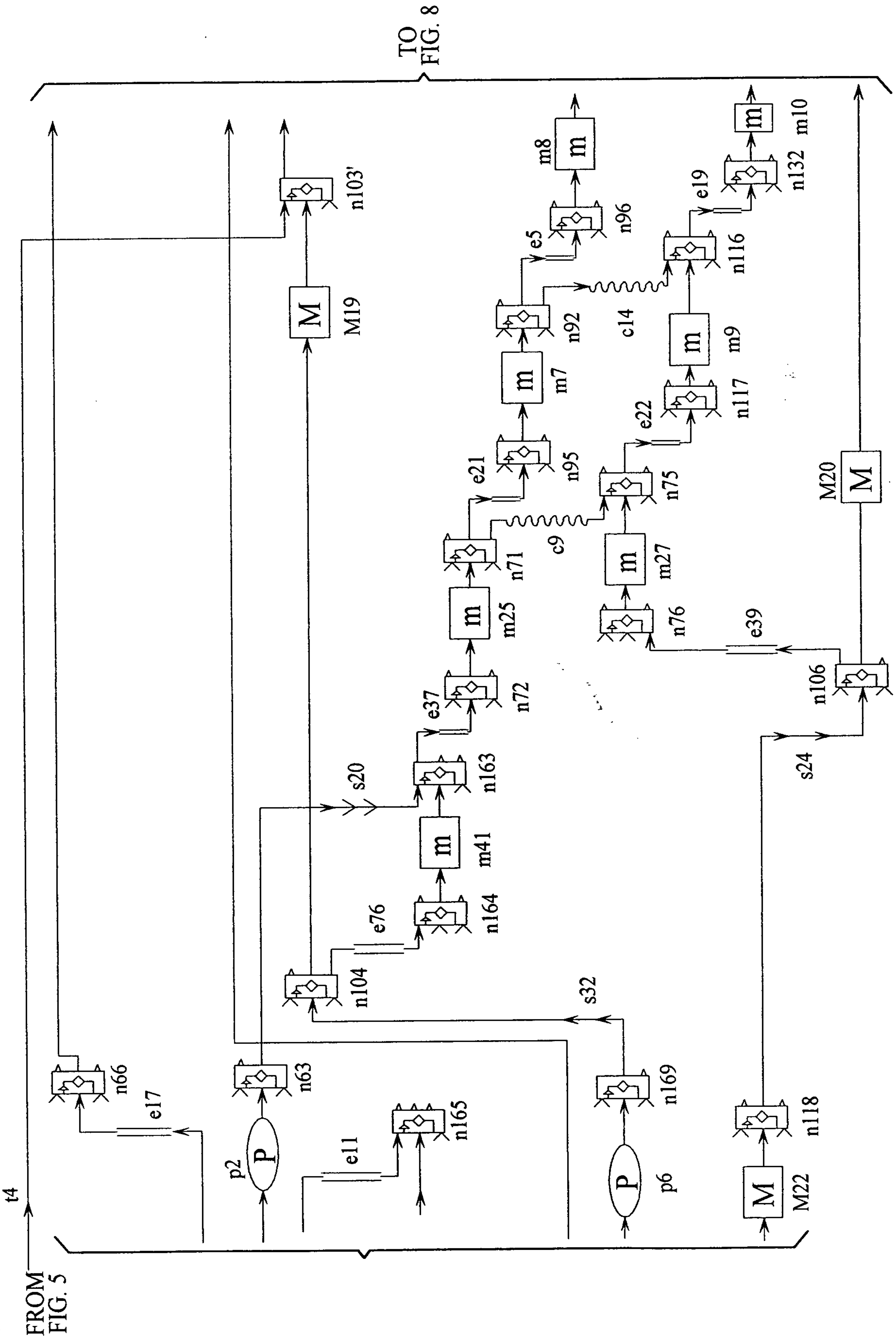

FROM FIG. 5
t4
TO FIG. 8
p2
P
p6
P
M22
M
n66
e17
n63
n165
e11
n169
n118
s32
n104
M19
M
n103'
e76
n164
m41
m
s20
n163
e37
n72
m25
m
n71
c9
e21
n95
m7
m
n92
e5
n96
m8
m
c14
n116
e19
n132
m10
m
n76
m27
m
n75
e22
n117
m9
m
e39
n106
s24
M20
M

FIG. 8

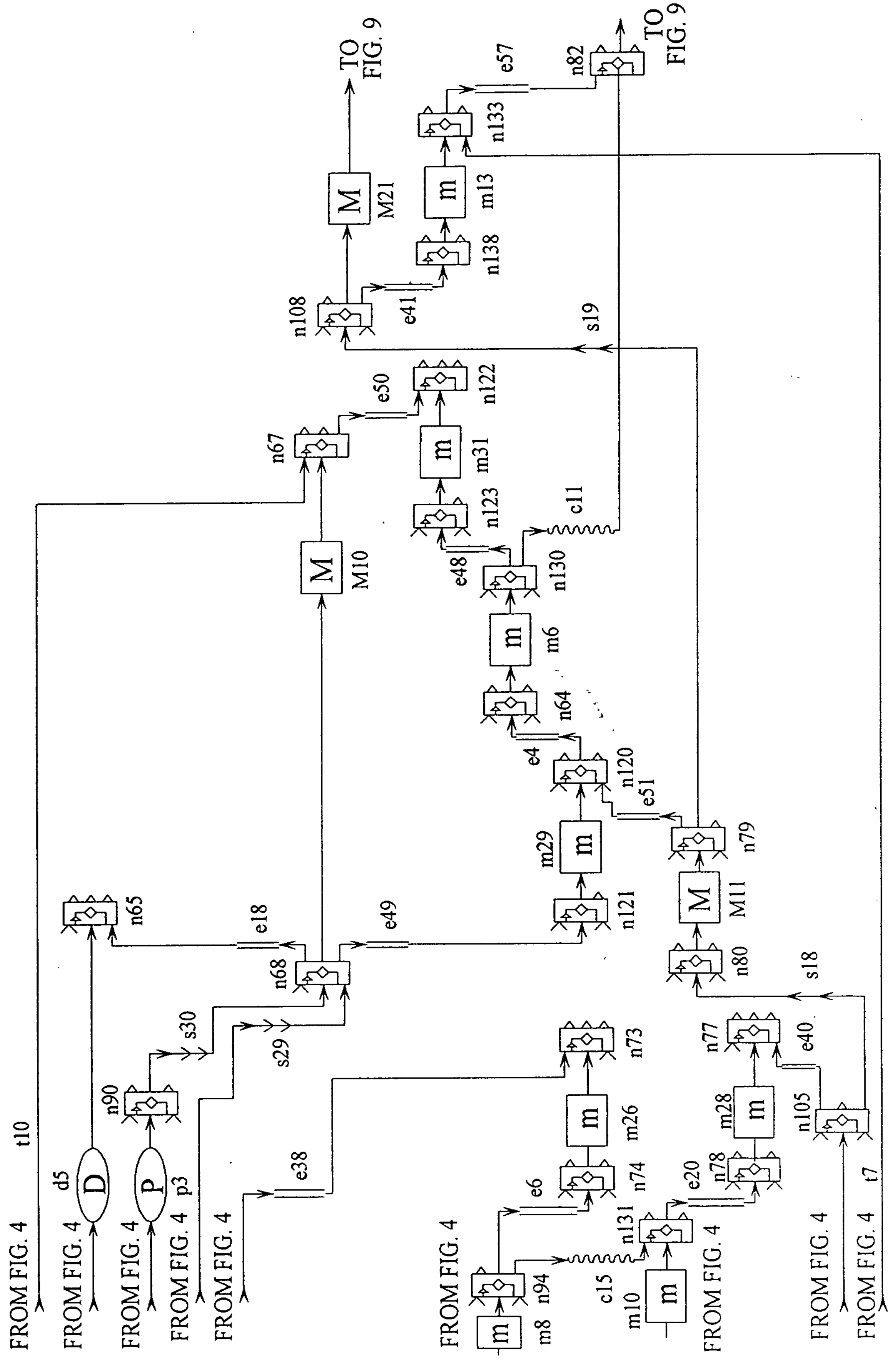
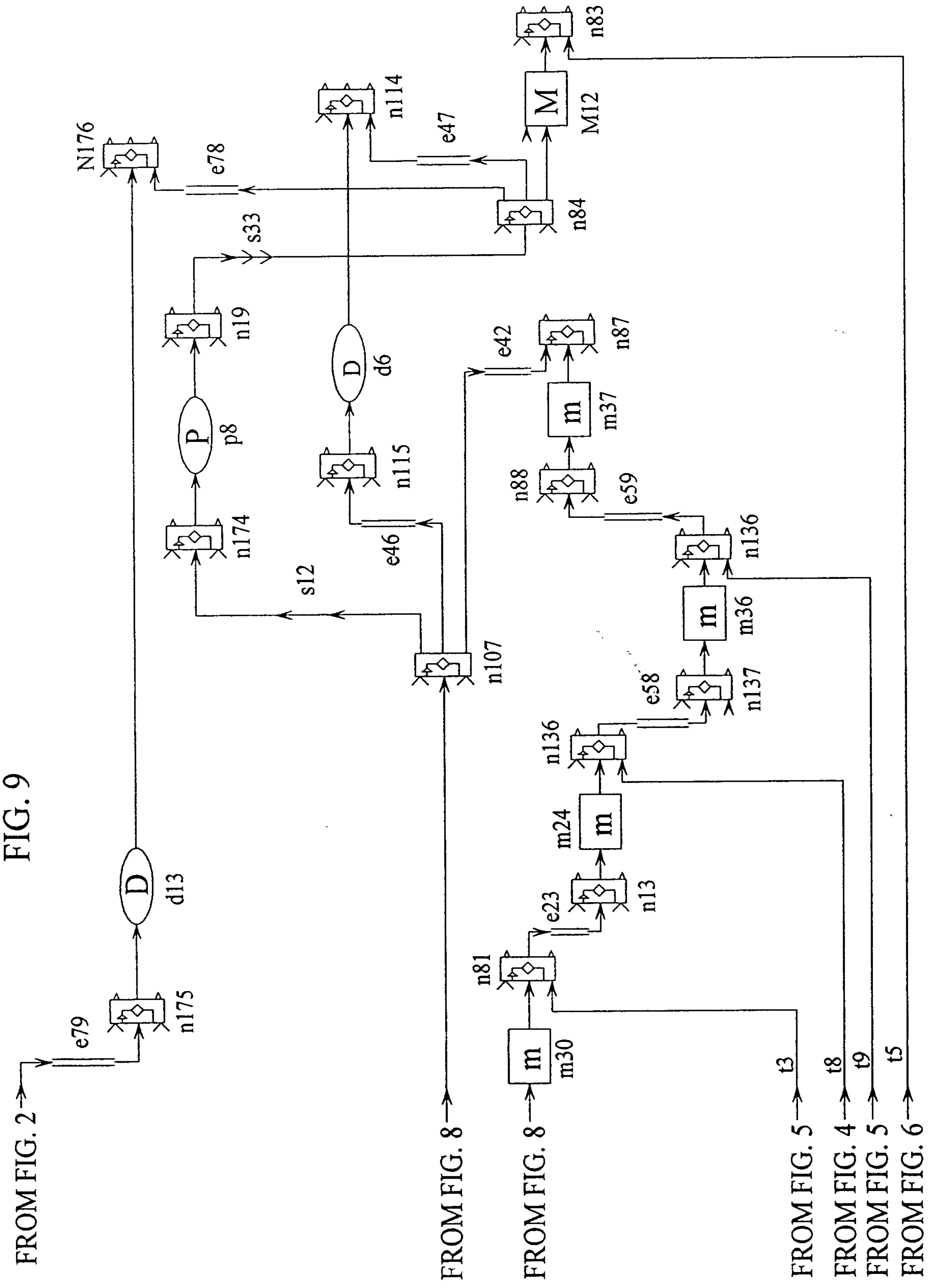

FROM FIG. 4
t10
FROM FIG. 4
d5
D
FROM FIG. 4
P
p3
FROM FIG. 4
FROM FIG. 4
e38
n90
s30
s29
n65
e18
n68
e49
M
M10
n67
e50
n122
m
m31
n123
n121
m
m29
n120
e4
n64
m
m6
n130
e48
c11
n108
e41
n138
m
m13
n133
M
M21
TO FIG. 9
e57
n82
TO FIG. 9
s19
n79
e51
M
M11
n80
s18
FROM FIG. 4
m
m8
n94
e6
n74
m
m26
n73
c15
n131
m
m10
FROM FIG. 4
e20
n78
m
m28
n77
e40
n105
FROM FIG. 4
FROM FIG. 4
t7

FIG. 9


FROM FIG. 2
e79
n175
D
d13
N176
FROM FIG. 8
n107
s12
n174
P
p8
n19
s33
e46
n115
D
d6
n114
e78
n84
e47
M
M12
n83
e42
FROM FIG. 8
m
m30
n81
e23
n13
m
m24
n136
e58
n137
m
m36
n136
e59
n88
m
m37
n87
FROM FIG. 5
t3
FROM FIG. 4
t8
FROM FIG. 5
t9
FROM FIG. 6
t5

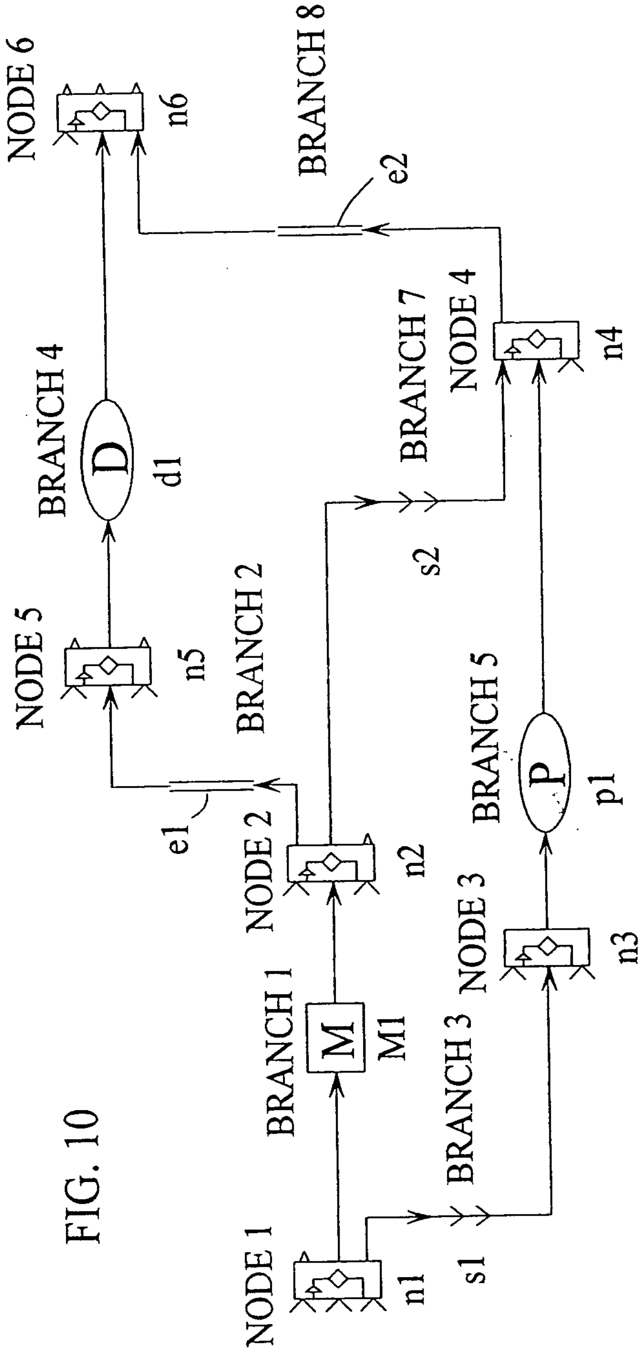

NODE 1
n1
BRANCH 1
M
M1
NODE 2
n2
e1
BRANCH 3
s1
NODE 3
n3
BRANCH 5
P
p1
NODE 5
n5
BRANCH 2
s2
BRANCH 4
D
d1
BRANCH 7
NODE 4
n4
NODE 6
n6
BRANCH 8
e2

FIG. 10

FIG. 11

		G	H
1	EVENTS	ON	OFF
2	GOB INTERCEPTOR	334	14
3	BLANKS CLOSE	324	130
4	BLANKS OPEN	130	321
5	PLUNGER UP	33	123
6	FIRST BAFFLE	9	125
7	PLUNGER DOWN	127	327
8	FUNNEL	1	150
9	SETTLE BLOW	1	1
10	PLUNGER COOLING	150	260
11	INVERT	200	260
12	NECKRING OPEN	274.5	283
13	REVERT	282	172
14	MOLDS CLOSE/OPEN	229	170
15	MOLD COOLING	10	150
16	FLOWHEAD	290	113
17	FINAL BLOW	348	120
18	TAKE OUT IN	137	197
19	TONGS CLOSE	178	78
20	TAKE OUT OUT	197	90

FIG. 12A

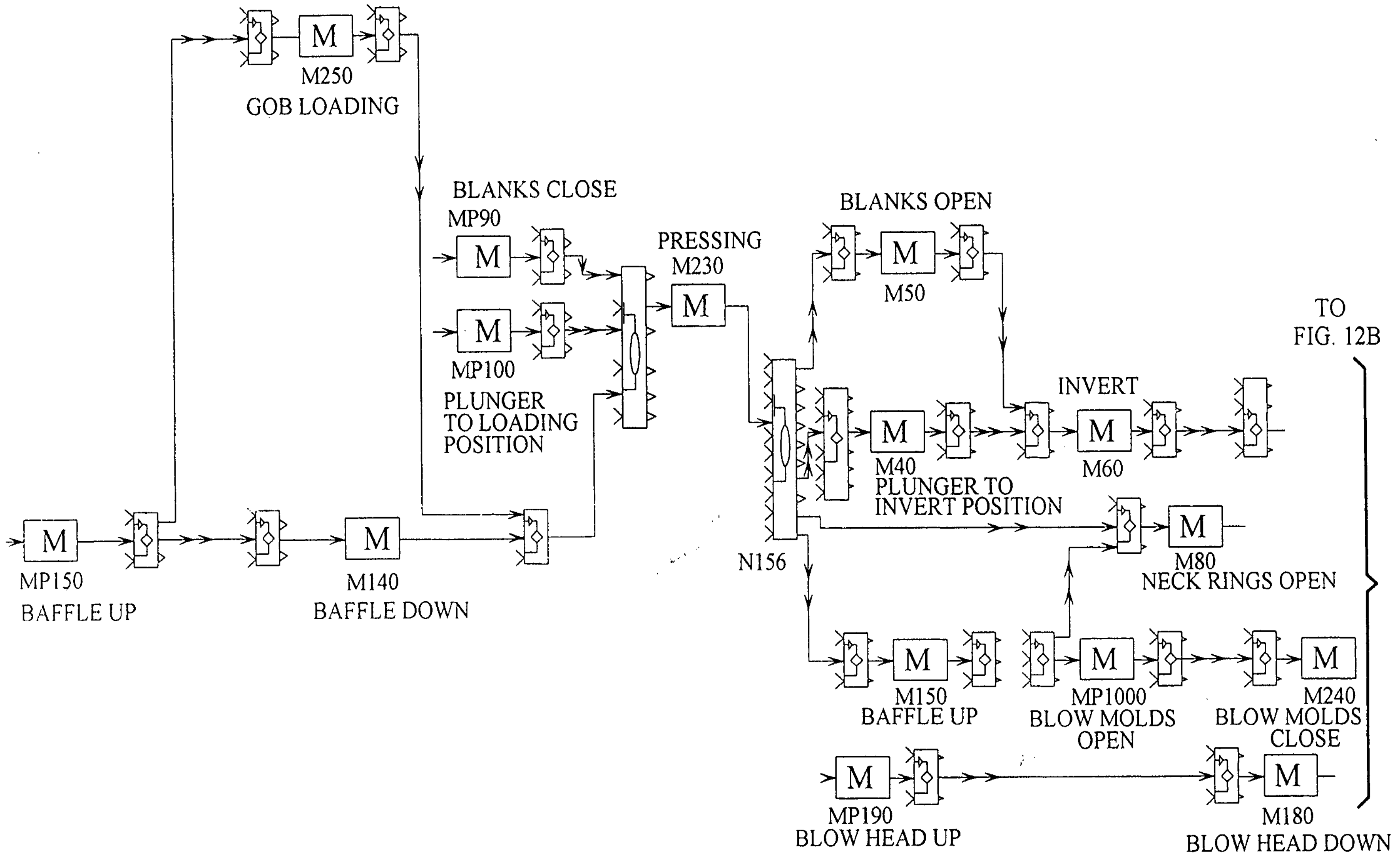

M
M250
GOB LOADING
BLANKS CLOSE
MP90
M
M
MP100
PLUNGER
TO LOADING
POSITION
PRESSING
M230
M
BLANKS OPEN
M
M50
M
M40
PLUNGER TO
INVERT POSITION
INVERT
M
M60
TO
FIG. 12B
M
MP150
BAFFLE UP
M
M140
BAFFLE DOWN
N156
M
M80
NECK RINGS OPEN
M
M150
BAFFLE UP
M
MP1000
BLOW MOLDS
OPEN
M
M240
BLOW MOLDS
CLOSE
M
MP190
BLOW HEAD UP
M
M180
BLOW HEAD DOWN

FIG. 12B

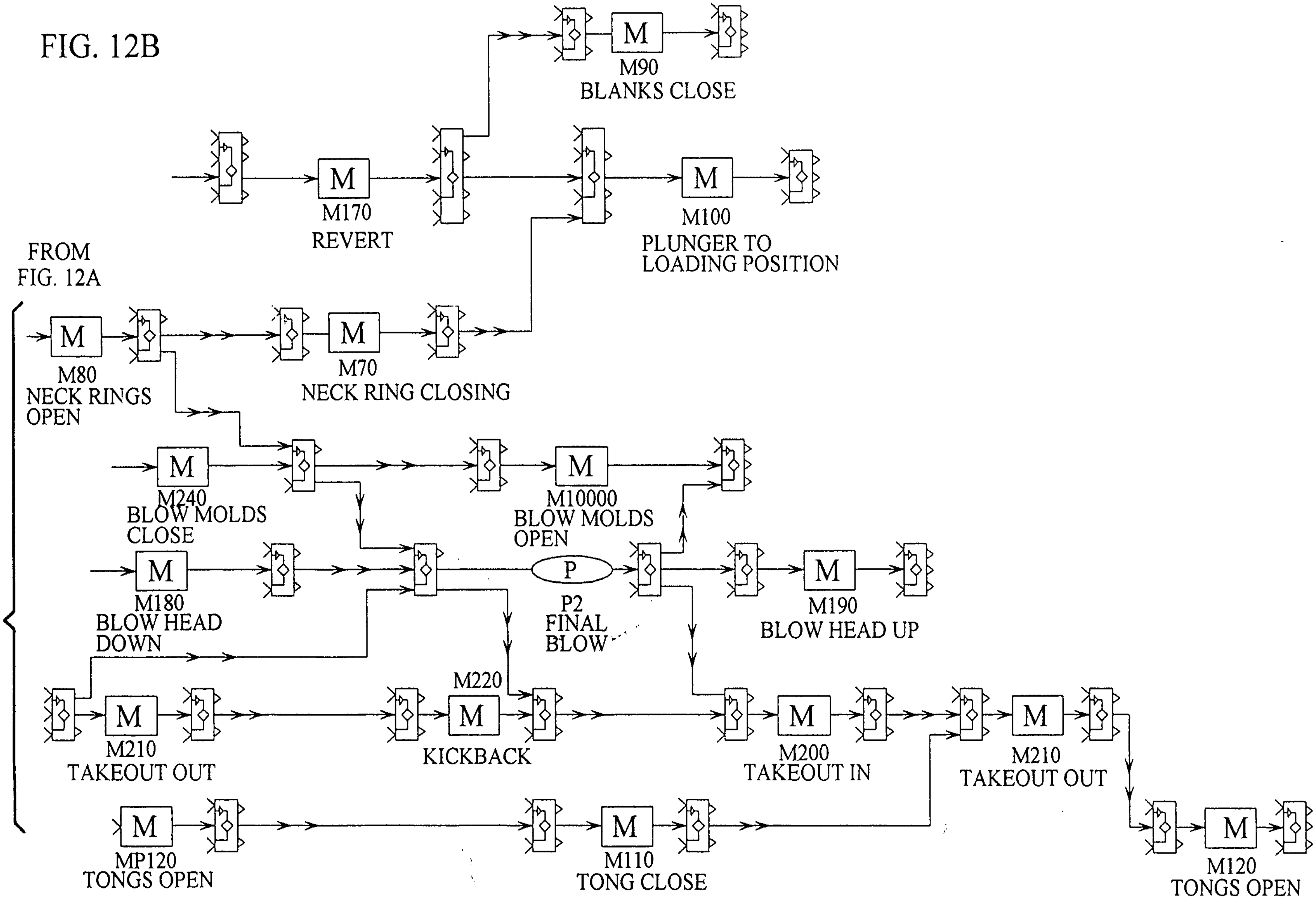

FROM
FIG. 12A
M90
BLANKS CLOSE
M
M170
REVERT
M100
PLUNGER TO
LOADING POSITION
M80
NECK RINGS
OPEN
M70
NECK RING CLOSING
M240
BLOW MOLDS
CLOSE
M10000
BLOW MOLDS
OPEN
M180
BLOW HEAD
DOWN
P
P2
FINAL
BLOW
M190
BLOW HEAD UP
M210
TAKEOUT OUT
M220
KICKBACK
M200
TAKEOUT IN
M210
TAKEOUT OUT
MP120
TONGS OPEN
M110
TONG CLOSE
M120
TONGS OPEN

FIG. 13

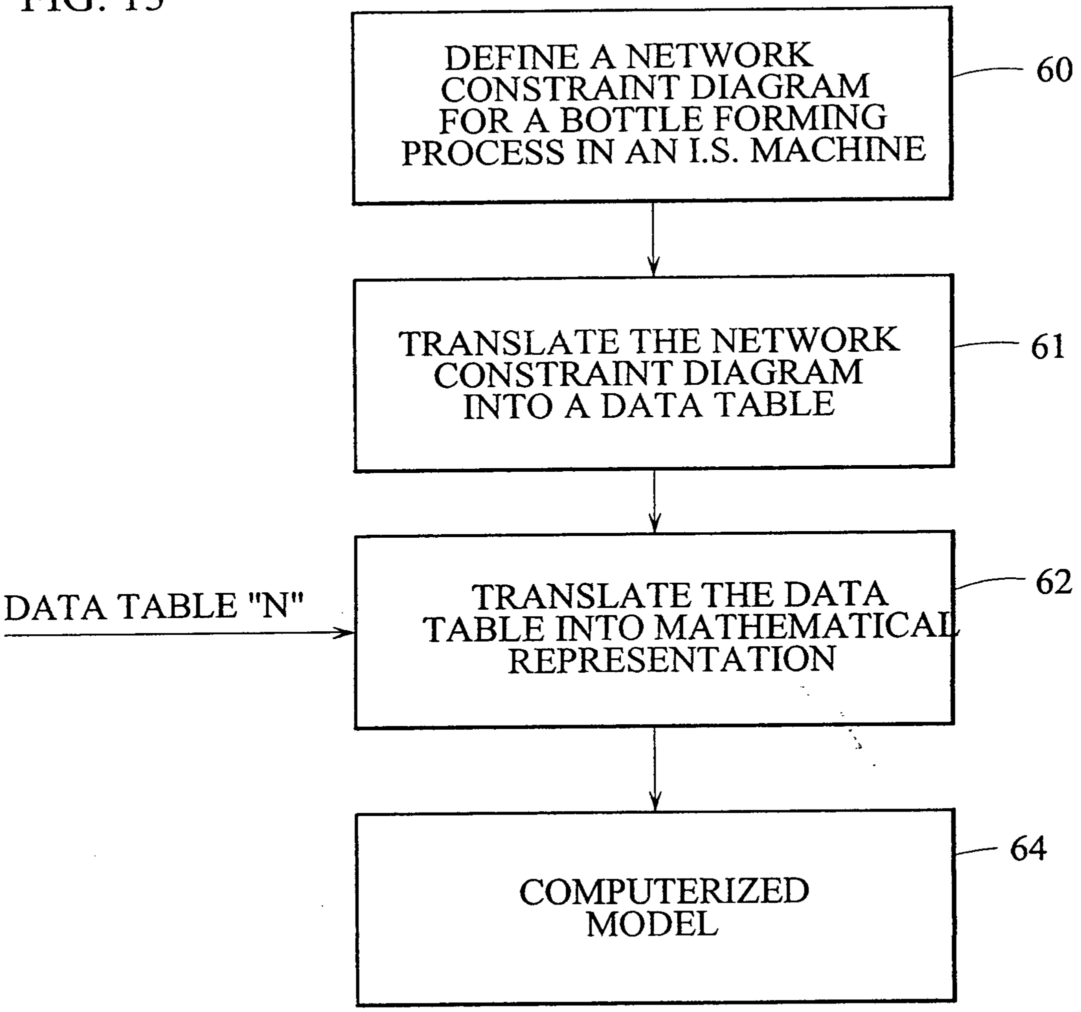

DEFINE A NETWORK CONSTRAINT DIAGRAM FOR A BOTTLE FORMING PROCESS IN AN I.S. MACHINE
60
TRANSLATE THE NETWORK CONSTRAINT DIAGRAM INTO A DATA TABLE
61
DATA TABLE "N"
TRANSLATE THE DATA TABLE INTO MATHEMATICAL REPRESENTATION
62
COMPUTERIZED MODEL
64

FIG. 14

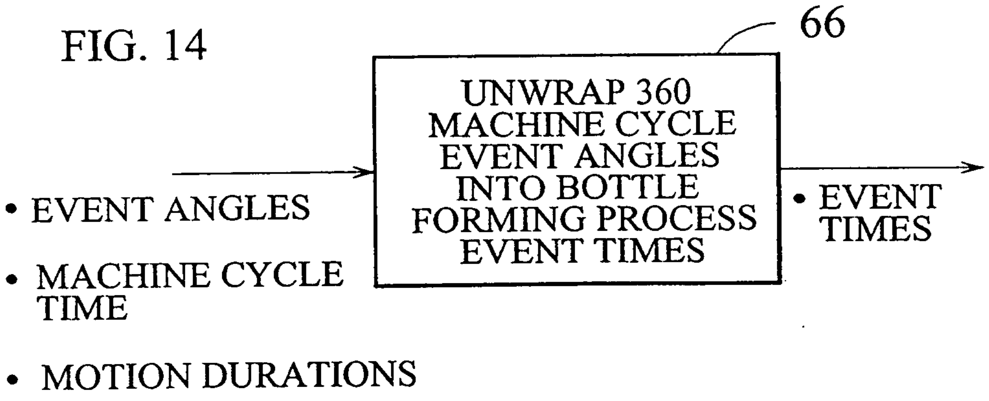

66
UNWRAP 360 MACHINE CYCLE EVENT ANGLES INTO BOTTLE FORMING PROCESS EVENT TIMES
• EVENT ANGLES
• MACHINE CYCLE TIME
• MOTION DURATIONS
• EVENT TIMES

FIG. 15

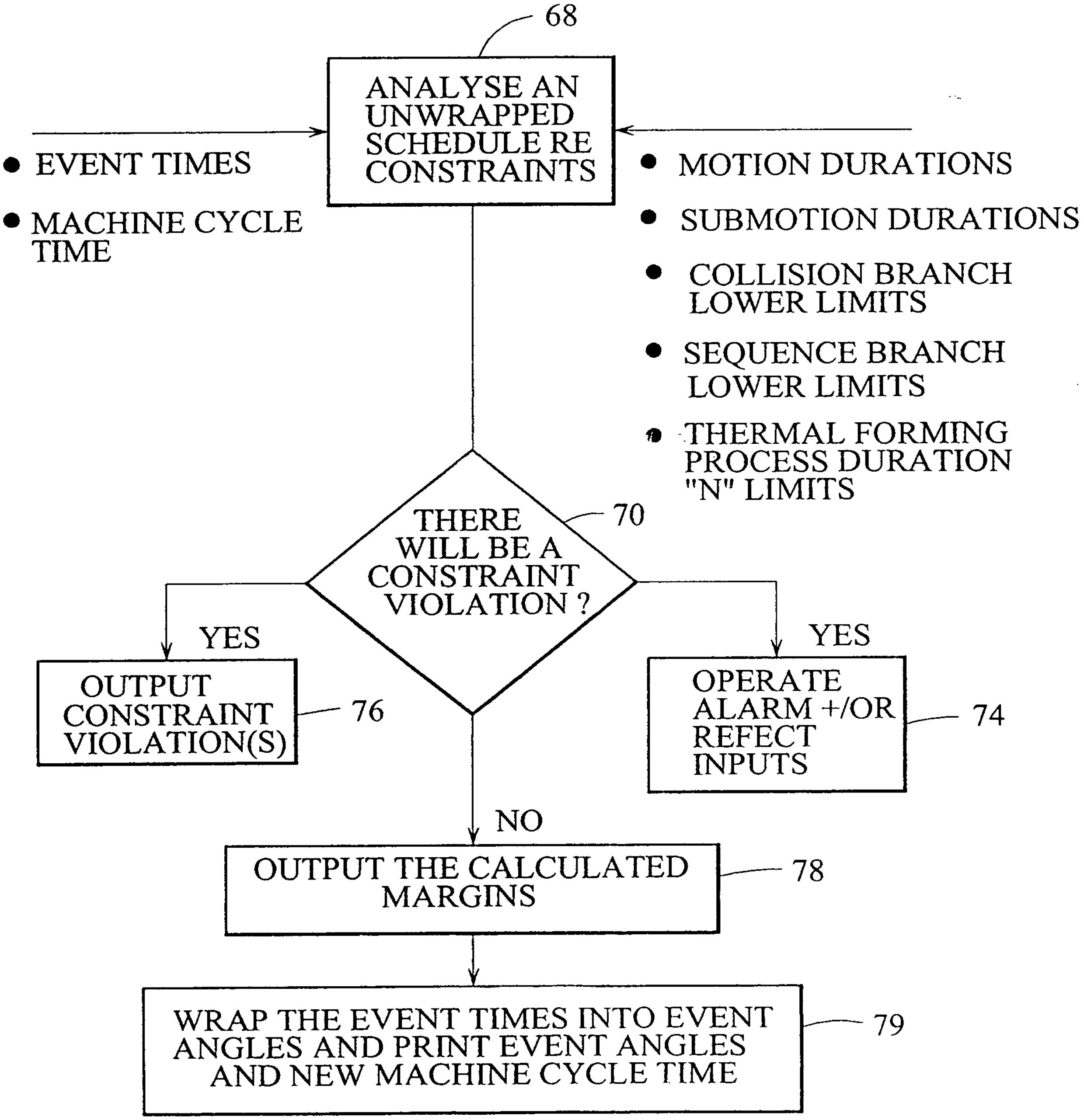

68
ANALYSE AN UNWRAPPED SCHEDULE RE CONSTRAINTS
• EVENT TIMES
• MACHINE CYCLE TIME
• MOTION DURATIONS
• SUBMOTION DURATIONS
• COLLISION BRANCH LOWER LIMITS
• SEQUENCE BRANCH LOWER LIMITS
• THERMAL FORMING PROCESS DURATION "N" LIMITS
THERE WILL BE A CONSTRAINT VIOLATION ?
70
YES
OUTPUT CONSTRAINT VIOLATION(S)
76
YES
OPERATE ALARM +/OR REFECT INPUTS
74
NO
OUTPUT THE CALCULATED MARGINS
78
WRAP THE EVENT TIMES INTO EVENT ANGLES AND PRINT EVENT ANGLES AND NEW MACHINE CYCLE TIME
79

FIG. 16

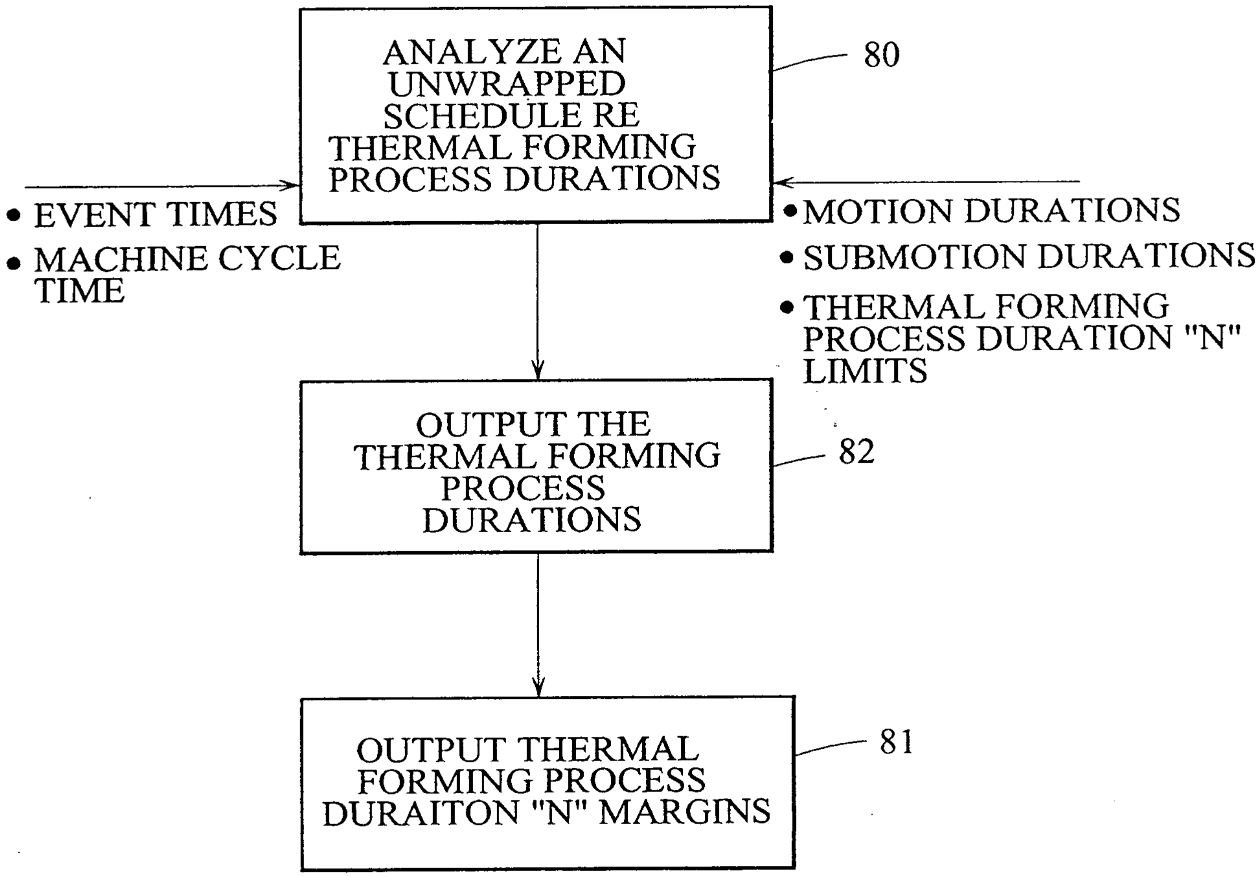

ANALYZE AN UNWRAPPED SCHEDULE RE THERMAL FORMING PROCESS DURATIONS
80
• EVENT TIMES
• MACHINE CYCLE TIME
• MOTION DURATIONS
• SUBMOTION DURATIONS
• THERMAL FORMING PROCESS DURATION "N" LIMITS
OUTPUT THE THERMAL FORMING PROCESS DURATIONS
82
OUTPUT THERMAL FORMING PROCESS DURAITON "N" MARGINS
81

FIG. 17

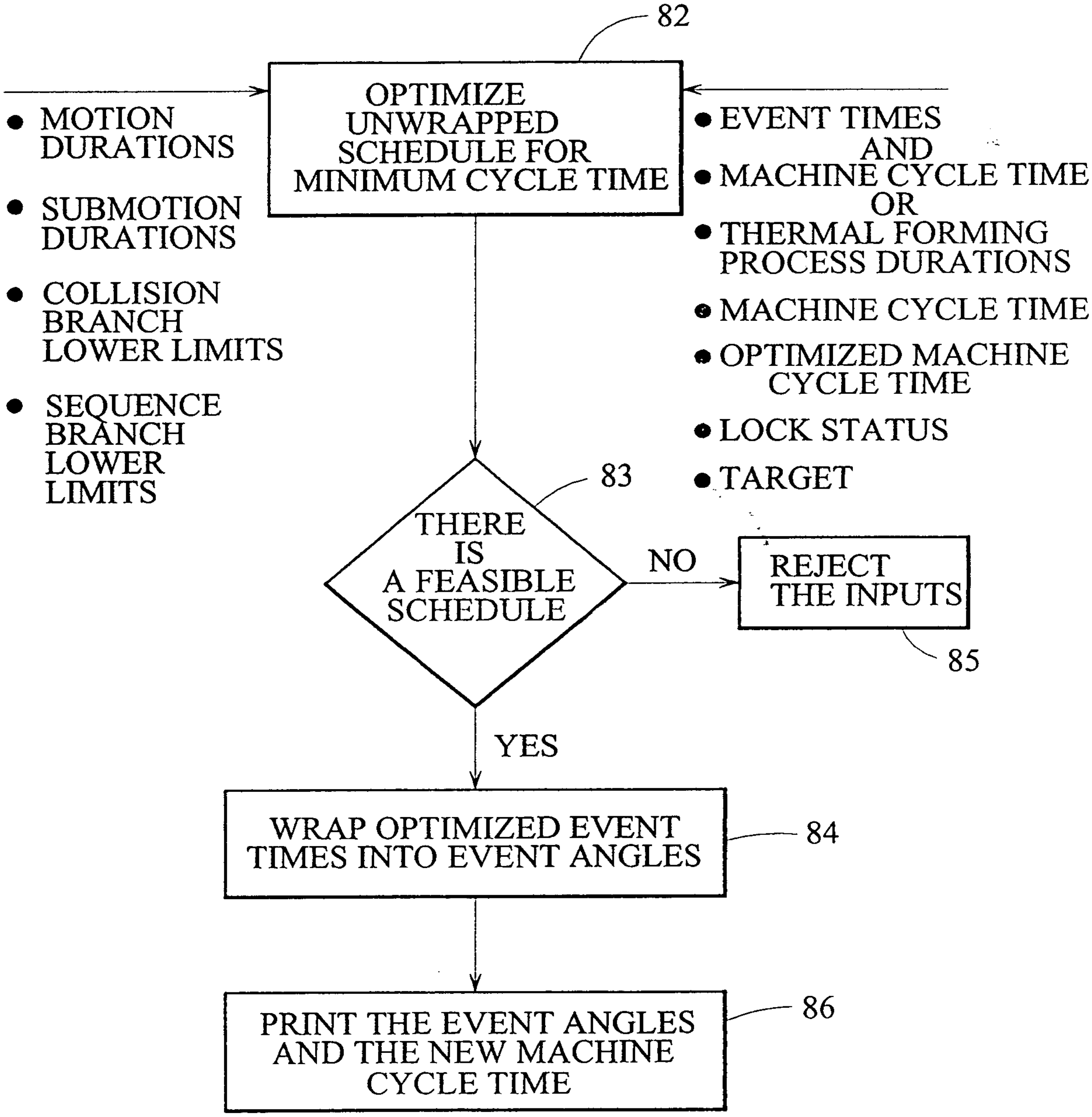

82
OPTIMIZE UNWRAPPED SCHEDULE FOR MINIMUM CYCLE TIME
● MOTION DURATIONS
● SUBMOTION DURATIONS
● COLLISION BRANCH LOWER LIMITS
● SEQUENCE BRANCH LOWER LIMITS
● EVENT TIMES
AND
● MACHINE CYCLE TIME
OR
● THERMAL FORMING PROCESS DURATIONS
● MACHINE CYCLE TIME
● OPTIMIZED MACHINE CYCLE TIME
● LOCK STATUS
● TARGET
83
THERE IS A FEASIBLE SCHEDULE
NO
REJECT THE INPUTS
85
YES
WRAP OPTIMIZED EVENT TIMES INTO EVENT ANGLES
84
PRINT THE EVENT ANGLES AND THE NEW MACHINE CYCLE TIME
86

FIG. 18

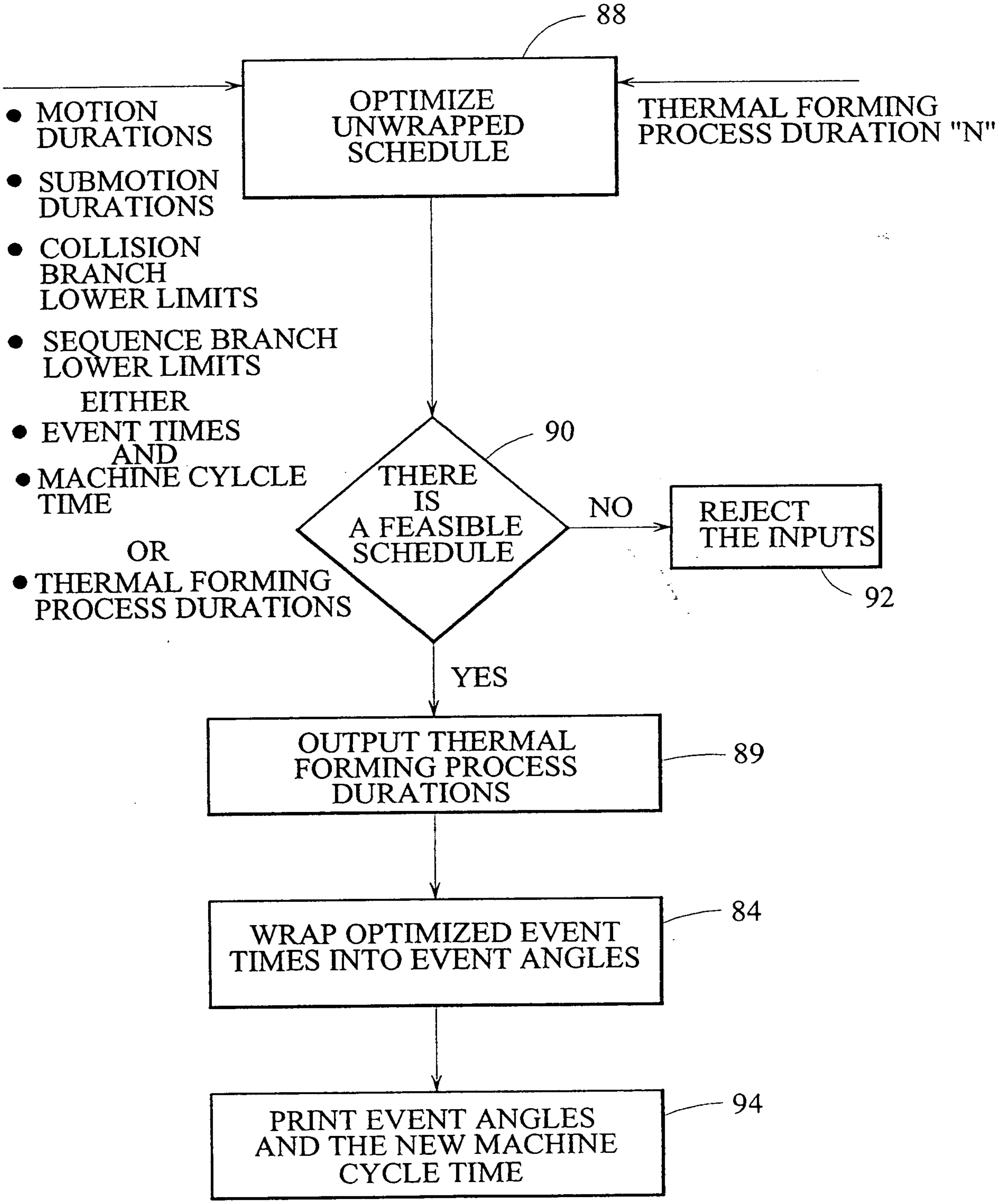

88
OPTIMIZE UNWRAPPED SCHEDULE
• MOTION DURATIONS
• SUBMOTION DURATIONS
• COLLISION BRANCH LOWER LIMITS
• SEQUENCE BRANCH LOWER LIMITS
EITHER
• EVENT TIMES
AND
• MACHINE CYLCLE TIME
OR
• THERMAL FORMING PROCESS DURATIONS
THERMAL FORMING PROCESS DURATION "N"
90
THERE IS A FEASIBLE SCHEDULE
NO
REJECT THE INPUTS
92
YES
OUTPUT THERMAL FORMING PROCESS DURATIONS
89
WRAP OPTIMIZED EVENT TIMES INTO EVENT ANGLES
84
PRINT EVENT ANGLES AND THE NEW MACHINE CYCLE TIME
94

FIG. 19

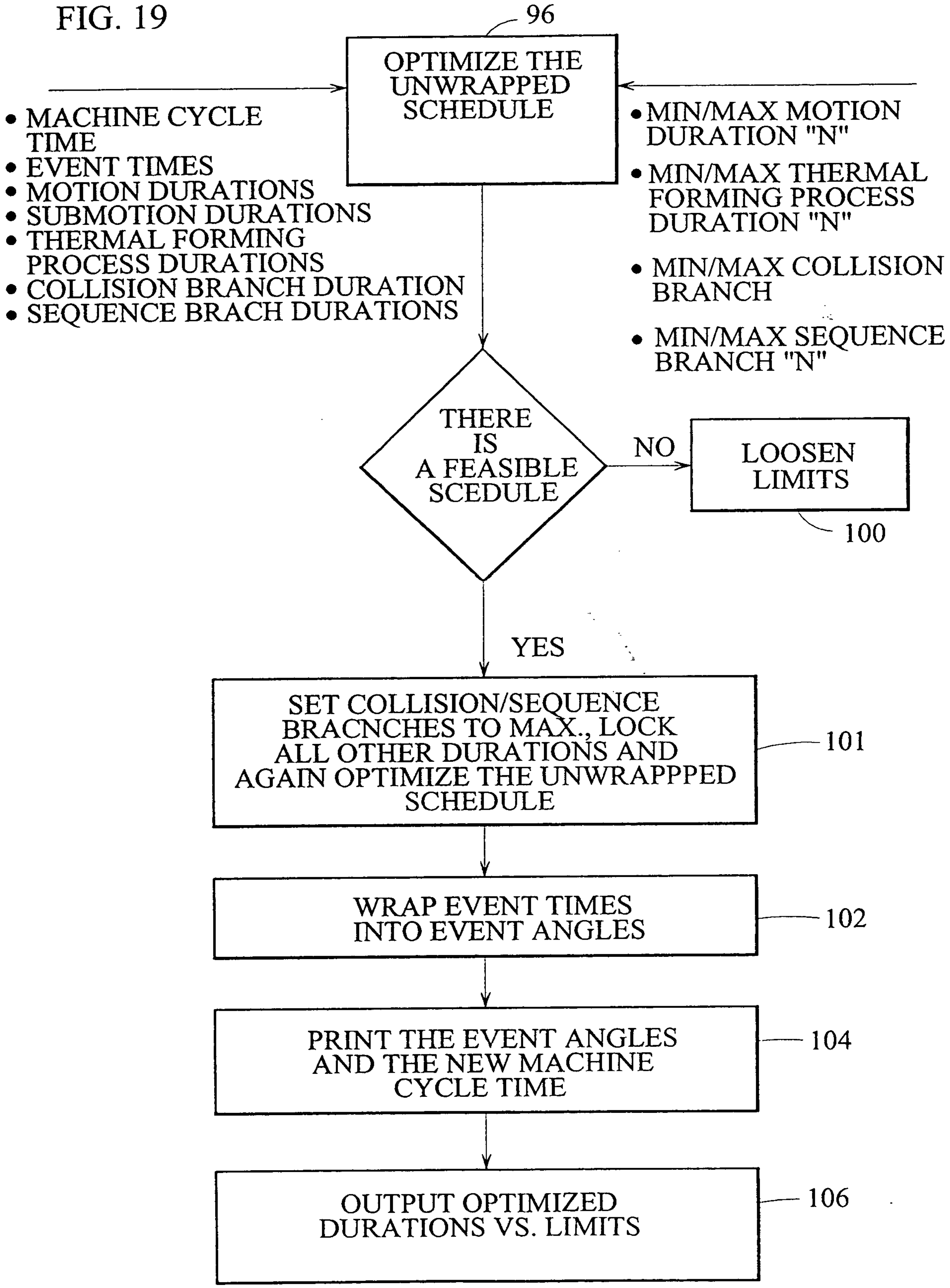

96
OPTIMIZE THE UNWRAPPED SCHEDULE
• MACHINE CYCLE TIME
• EVENT TIMES
• MOTION DURATIONS
• SUBMOTION DURATIONS
• THERMAL FORMING PROCESS DURATIONS
• COLLISION BRANCH DURATION
• SEQUENCE BRACH DURATIONS
• MIN/MAX MOTION DURATION "N"
• MIN/MAX THERMAL FORMING PROCESS DURATION "N"
• MIN/MAX COLLISION BRANCH
• MIN/MAX SEQUENCE BRANCH "N"
THERE IS A FEASIBLE SCEDULE
NO
LOOSEN LIMITS
100
YES
SET COLLISION/SEQUENCE BRACNCHES TO MAX., LOCK ALL OTHER DURATIONS AND AGAIN OPTIMIZE THE UNWRAPPPED SCHEDULE
101
WRAP EVENT TIMES INTO EVENT ANGLES
102
PRINT THE EVENT ANGLES AND THE NEW MACHINE CYCLE TIME
104
OUTPUT OPTIMIZED DURATIONS VS. LIMITS
106

FIG. 20

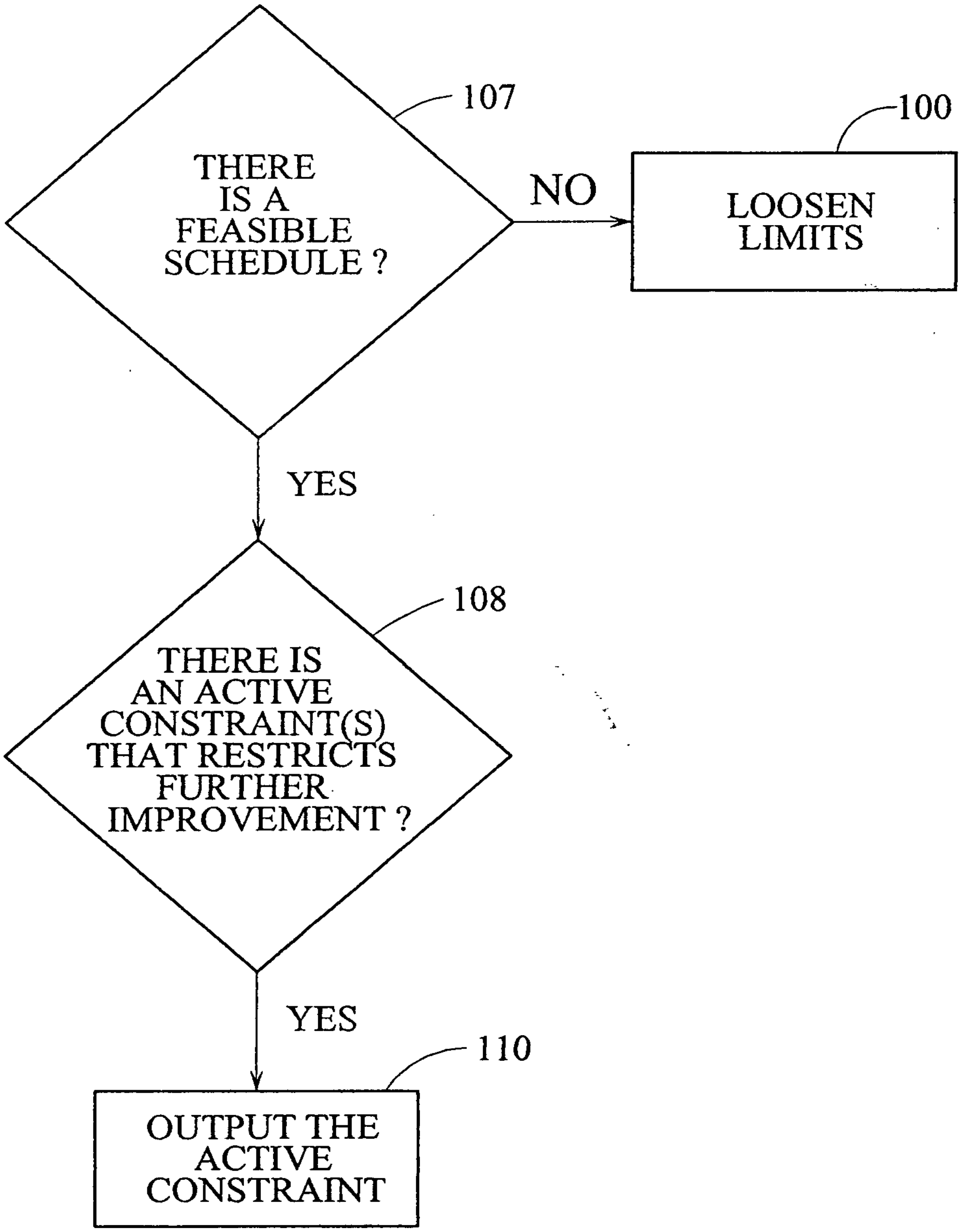
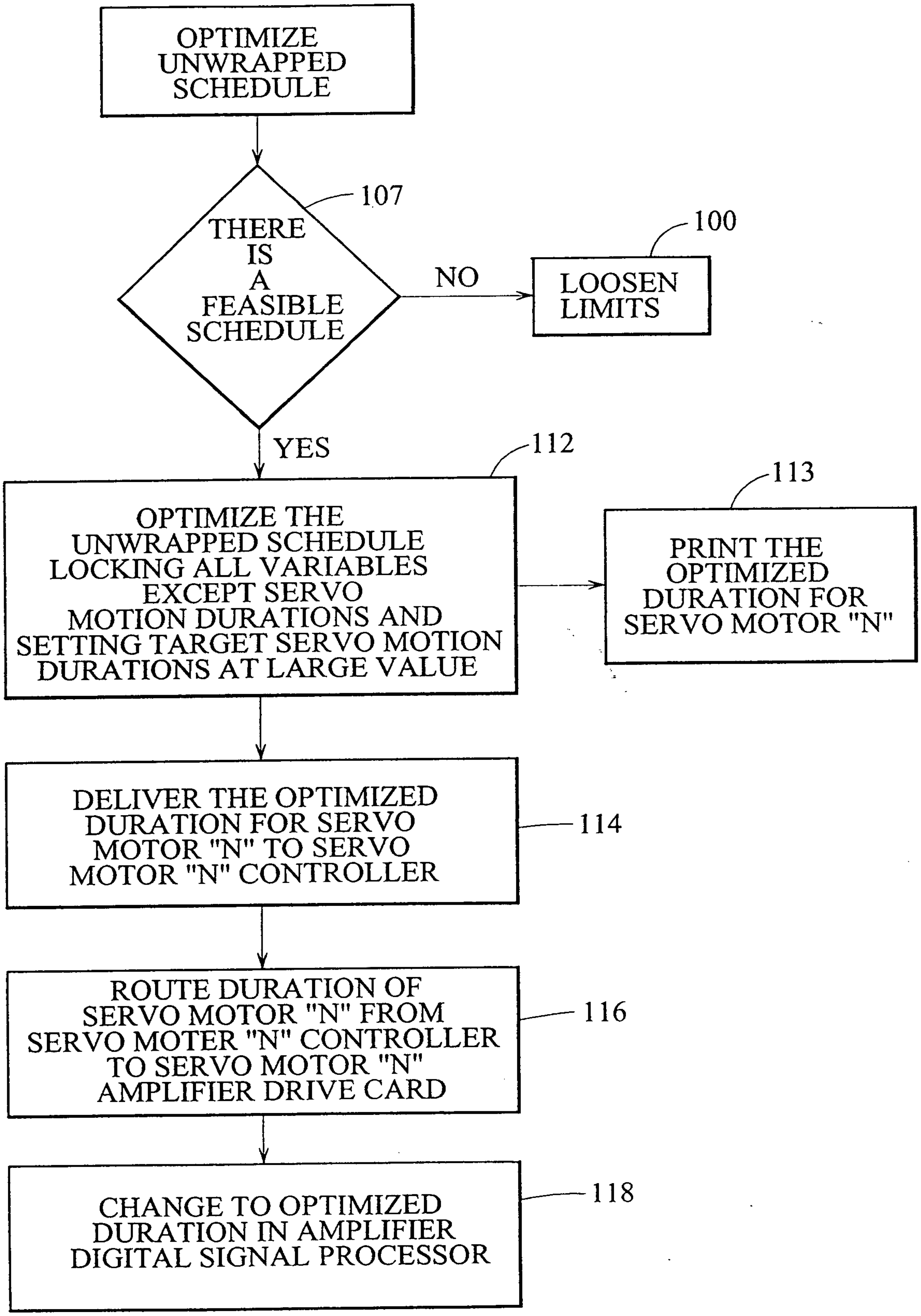

107
100
THERE IS A FEASIBLE SCHEDULE ?
NO
LOOSEN LIMITS
YES
108
THERE IS AN ACTIVE CONSTRAINT(S) THAT RESTRICTS FURTHER IMPROVEMENT ?
YES
110
OUTPUT THE ACTIVE CONSTRAINT

FIG. 21


OPTIMIZE UNWRAPPED SCHEDULE
107
THERE IS A FEASIBLE SCHEDULE
NO
100
LOOSEN LIMITS
YES
112
OPTIMIZE THE UNWRAPPED SCHEDULE LOCKING ALL VARIABLES EXCEPT SERVO MOTION DURATIONS AND SETTING TARGET SERVO MOTION DURATIONS AT LARGE VALUE
113
PRINT THE OPTIMIZED DURATION FOR SERVO MOTOR "N"
DELIVER THE OPTIMIZED DURATION FOR SERVO MOTOR "N" TO SERVO MOTOR "N" CONTROLLER
114
ROUTE DURATION OF SERVO MOTOR "N" FROM SERVO MOTER "N" CONTROLLER TO SERVO MOTOR "N" AMPLIFIER DRIVE CARD
116
CHANGE TO OPTIMIZED DURATION IN AMPLIFIER DIGITAL SIGNAL PROCESSOR
118